

Microorganisms in the Food Industry

Mold, yeast, and bacteria are the chief microorganisms that cause food spoilage. Mold usually grows on the surface of foods and has a fuzzy appearance. If only a small amount has grown on a food's surface, the mold can be removed and the remaining food eaten. In larger amounts, mold growth produces undesirable changes throughout the food. The growth of yeast, a one-celled plant, is slowed by low temperatures and destroyed at the boiling point. Sugar levels of at least 65% also inhibit yeast growth. Some, commonly called germs, are harmful to us because of the role they play in causing diseases. This unit focuses on bacteria. Subsequent units will present molds and yeasts.

Microorganism Activity

Microorganisms are also responsible for some extremely undesirable changes in food. Warmth, moisture, and food facilitate the growth of microorganisms. The purpose of preserving food is to limit or prevent growth of microorganisms. There are many examples of microorganisms being responsible for beneficial changes in food. A certain mold is used to make Gorgonzola, Blue, and Roquefort cheeses. The process of making sour cream and yogurt utilizes specific kinds of bacteria. In bread making, yeast transforms sugar into ethyl alcohol and carbon dioxide. To make meat more tender, the enzymes in papain are used in commercial meat tenderizers to break down the connective tissue.

Bacteria

Bacteria is a special focus of this unit. (Molds and yeasts are discussed in more detail in the next unit).

Bacteria are single-celled organisms that can grow with or without air. Bacteria make up the largest group of microorganisms. People often think of bacteria only in terms of germs and the harm they do. Actually, only a small number of bacteria types are pathogenic (disease causing). Most are harmless, and many are helpful.

There are thousands of different kinds of bacteria. Some differ only slightly, and it takes a highly-trained person to identify them. There are also groups which differ greatly in growth habits and appearance and are quite easily identified. Regardless of minor differences, most bacteria can be classified according to five basic cell shapes- Spiral or Spirilla, Rod or Bacilli, Round or Cocci, Comma or Vibrio, and Filamentous. (See the BACTERIA CELL SHAPES overhead transparencies.)

In addition to their different shapes, bacteria cell arrangement varies. For example, some cocci are always grouped in pairs (diplococci). Others are arranged in chains (streptococci). Still others are bunched (staphylococci). (See BACTERIAL CELL ARRANGEMENTS overhead transparencies.)

Diplococci are a kind of bacteria which cause pneumonia. Streptococci are often associated with strep throat. Staphylococci are familiar to many because of their role in staph infections and some cases of food poisonings.

Bacteria vary somewhat in size, but the average is about $\frac{1}{25,000}$ inch. In other words, 25,000 bacteria laid side by side would occupy only one inch of space. One cubic inch is big enough to hold nine trillion average size bacteria-about 3,000 bacteria for every person on earth.

Bacterial Eating Habits

Bacteria and other microorganisms need food in order to grow and multiply, but the different types vary in their food needs. Although some bacteria make their own food, as plants do, many rely on outside food sources, and nearly everything humans consider as food can also be used as food by some type of bacteria.

To be used by bacteria, a food substance must be manufactured inside the one-celled organism, or food from an outside source must pass into the cell of the microorganism where the food can be processed into energy and new cell material. Because many foods are too complex to move into a bacterial cell, most of them must be broken down into simpler substances. Enzymes do this by acting as catalysts and increasing the rate of biochemical reactions.

A catalyst initiates a chemical reaction but is not used up in the process. A catalyst also enables a chemical reaction to proceed under milder conditions than would otherwise be possible. The enzyme moves through the cell wall to break down food on the outside into a form bacteria can use. Enzymes are found within living bacterial and other cells.

Growth and Importance to Food Industry

Bacteria are single cells, and like all cells they reproduce by a process called binary fission-one cell divides and becomes two. (See BINARY FISSION overhead transparency.) Some bacteria can reproduce at a very rapid rate under proper conditions. If food and moisture are adequate and the temperature is right, certain bacteria can reproduce in as little as 20 minutes. Within 20 minutes, one cell becomes two; in 40 minutes, there will be four, and so on. In only eight hours, the original cell will have multiplied to nearly 17 million new bacteria. Of course, conditions don't remain favorable for such a rate of reproduction for very long. If they did, people could be buried in bacterial cells.

The number of certain kinds of bacteria in and on food we eat is very important. Plate counting, a technique by which colonies of bacteria are grown from single cells on nutrient agar, makes it possible to determine the number of bacteria in a food sample without the aid of a microscope.

A second important method of classifying bacteria is by their ability to grow and reproduce at various temperatures. Some are cold loving and grow well under refrigeration. Called psychophilic bacteria, this group grows at temperatures less than 50 F. They are responsible for many types of spoilage in refrigerated foods, such as slime formation on meats and ropiness in milk.

The second group-mesophilic bacteria-includes those which cause disease and food poisoning. They grow only at moderate temperatures of 50 F to 110 F. You can see why it is so important to store unprocessed foods under refrigeration.

The third group-called thermophile-grows well at temperatures between 110 F to 140 F. These bacteria can cause spoilage in underprocessed canned foods. Generally bacteria require food, warmth, water, and time in order to grow. (See BACTERIAL CONDITIONS FOR GROWTH overhead transparency.)

An important thing to consider in the growth of bacteria is the ability of certain types to produce spores. A spore is a dormant or resting state of a bacterial cell. (See BACTERIAL SPORES overhead transparency.)

There are certain basic differences between spores and active or vegetative (these terms refer to growing or having the power to grow and reproduce) bacterial cells. Spores are not easily killed. In

fact, conditions which will quickly kill active bacteria have little or no effect on spores. A temperature of 180 F will kill bacterial cells within minutes, but the same bacteria, once formed into spores, can resist the 180 F temperature indefinitely. This knowledge is applied in food preparation in that all processing times for canned foods are calculated by using both the time and temperature required to kill bacterial spores.

As noted earlier, microorganisms are essential in the production of certain foods. Reactions caused by bacteria are central to producing many foods we enjoy daily. For examples, bacteria are responsible in whole or in part for the following:

Cocoa, Coffee Olives Cheeses

Pickles Yogurt Sauerkraut

Vinegar Vanilla Buttermilk

Some bacteria aid human beings; some are necessary for good health (Excerpted from ON FOOD AND COOKING - THE SCIENCE AND LORE OF THE KITCHEN: Harold McGee, Charles Scribner's Sons, New York, 1984.)

Acid-producing bacteria such as *Lactobacillus bulgaricus* and *Streptococcus thermophilus*, when added to milk and kept at controlled temperatures (110 F or 43 C) and time controlled (usually 4 hours), will produce a milk product known as yogurt. The two kinds of bacteria consume the lactose in milk as an energy source, excrete lactic acid as a waste product, and produce a safe and edible product-yogurt.

Sour cream and cottage cheese can be made without the help of bacteria by purposely adding cultures as is done in commercial ventures. Bacteria derived from the atmosphere will also sour the milk and, over time, will cause it to curdle. Plain milk and cream is fairly stable when heated, but prolonged heating and acids added from other foods cause the casein micelles and whey proteins to become unstable and curd.

Commercially, cottage cheese and other cheeses are produced by two methods: one uses rennet (an enzyme that coagulates milk) to curdle the milk, the other uses lactic bacteria. Cheese making depends on the bacteria that produce lactic acids to cause the casein micelles to aggregate, trapping fat globules and the whey in the protein. *Streptococcus lactis* is used to produce buttermilk commercially.

Yogurt Facts

A. Yogurt is milk that has been made sour under specific conditions:

1. Two types of bacteria are involved: *Lactobacillus bulgaricus* and *Streptococcus thermophilus*. They are different from other bacteria that cause milk to spoil.
2. The bacteria use sugar (lactose) found in the milk for food. As they consume the lactose, an acid (lactic acid) is released. The sweet lactose becomes sour. This gives yogurt its flavor. (Note: lactic acid bacteria can be purchased in yogurt cultures.)
3. The bacteria can grow in whole or skim milk, but they grow better if the milk is warm. The water content of the milk and the sugar (lactose) and the warm temperature combine to provide a perfect condition for the bacteria to grow. Cold temperatures slow the process.

4. The high acid content of the bacteria and milk mixture causes proteins in the milk to break apart and form curds. (Curds are easy to see in cottage cheese.) At 100 F or 38 C curds will form in about 5 hours. If yogurt is placed in a refrigerator, curd formation stops.

5. Adding powdered milk (usually skim milk) to the milk mixture adds more protein and more curds result. (Boiling the milk to let some water evaporate will do the same thing.)

A. Yogurt is served in many different ways:

1. It is a main dish and/or a dessert.
2. Fruits, herbs, and spices may be added.
3. It is a good topping or dip for fruits and vegetables.
4. It can be added directly to batters.

B. Yogurt contains a very delicate balance of curds and whey. Heat, salt, acids, and vigorous stirring will disrupt the balance causing curds to form in protein clusters making the yogurt look odd and changing texture.

C. If yogurt is stirred and returned to a refrigerator, water (whey) will separate from the curds, and a day or two later, the water will form in a layer on top of the yogurt.

Special note about soy sauce

(Source: On Food and Cooking: The Science and Lore of the Kitchen, Harold McGee Scribners Publishing, 1984. p. 253.)

Soy sauce is a popular fermented product made from defatted soy flakes mixed with wheat and salt. It can be made two ways:

1. Roasted soy meal and crushed roasted wheat are fermented for 3 days using aspergillus mold. Lactobacilli (a bacteria) and yeasts (fungi) are added to the brine which is fermented for another 6 months to 1 year. The solution is then filtered and pasteurized. The settlement cake is used for cattle feed and the liquid is soy sauce.
2. Hydrochloric acid is added to roasted soy meal which is then hydrolyzed for 8 to 10 hours. Sodium carbonate is added to adjust the pH to 4.7. The mixture is then filtered to produce the soy sauce.